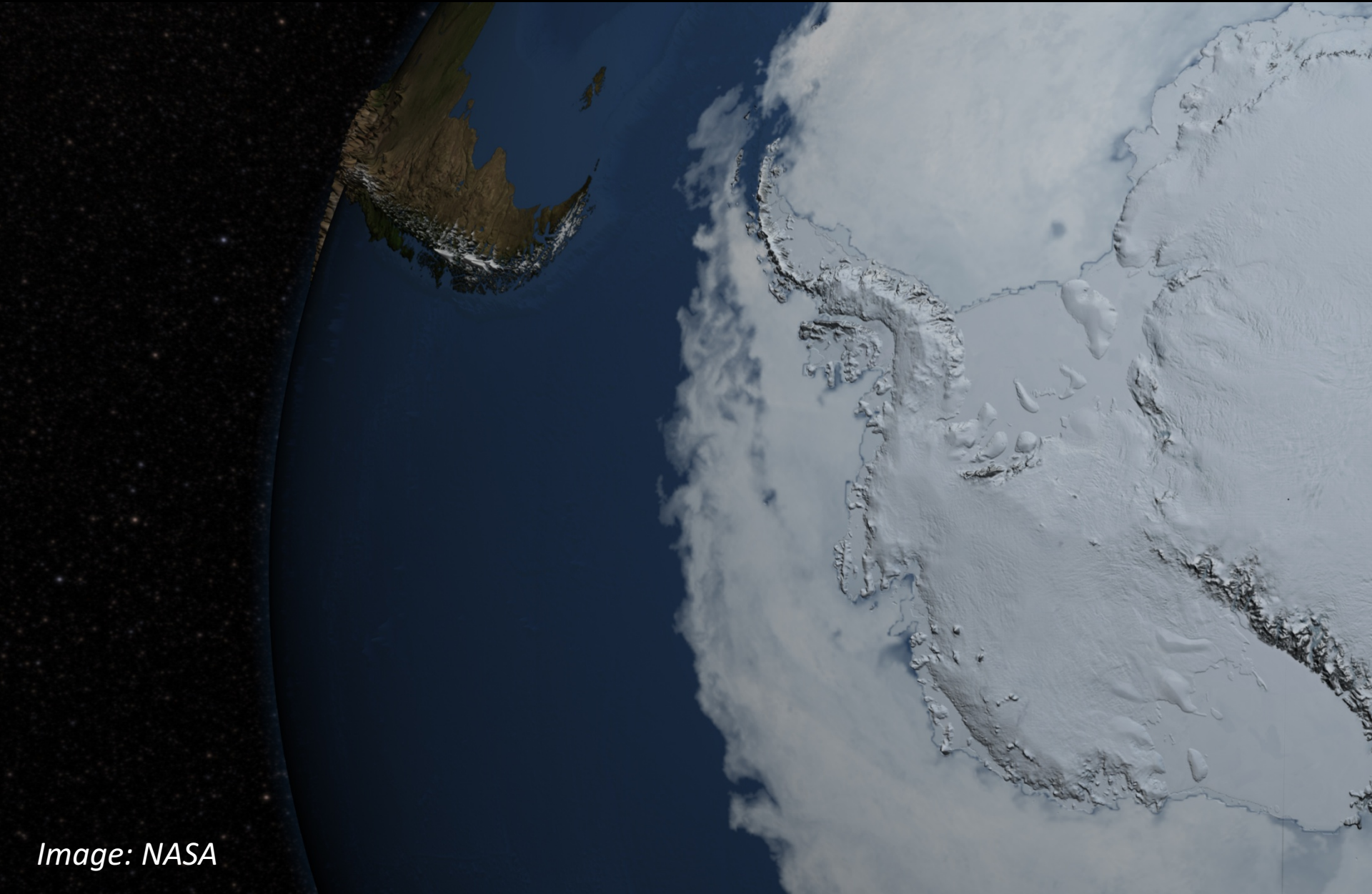


# Reconstructing 250 years of snow accumulation over West Antarctica

Brooke Medley<sup>1</sup>, Liz Thomas<sup>2</sup>

<sup>1</sup>NASA GSFC, <sup>2</sup>BAS



*Image: NASA*

# A key component

Ice sheet mass *GAIN*

– *Present? Past or future?*

Surface elevation change

– *Direct & indirect (firn compaction)*

Constrain ice dynamics

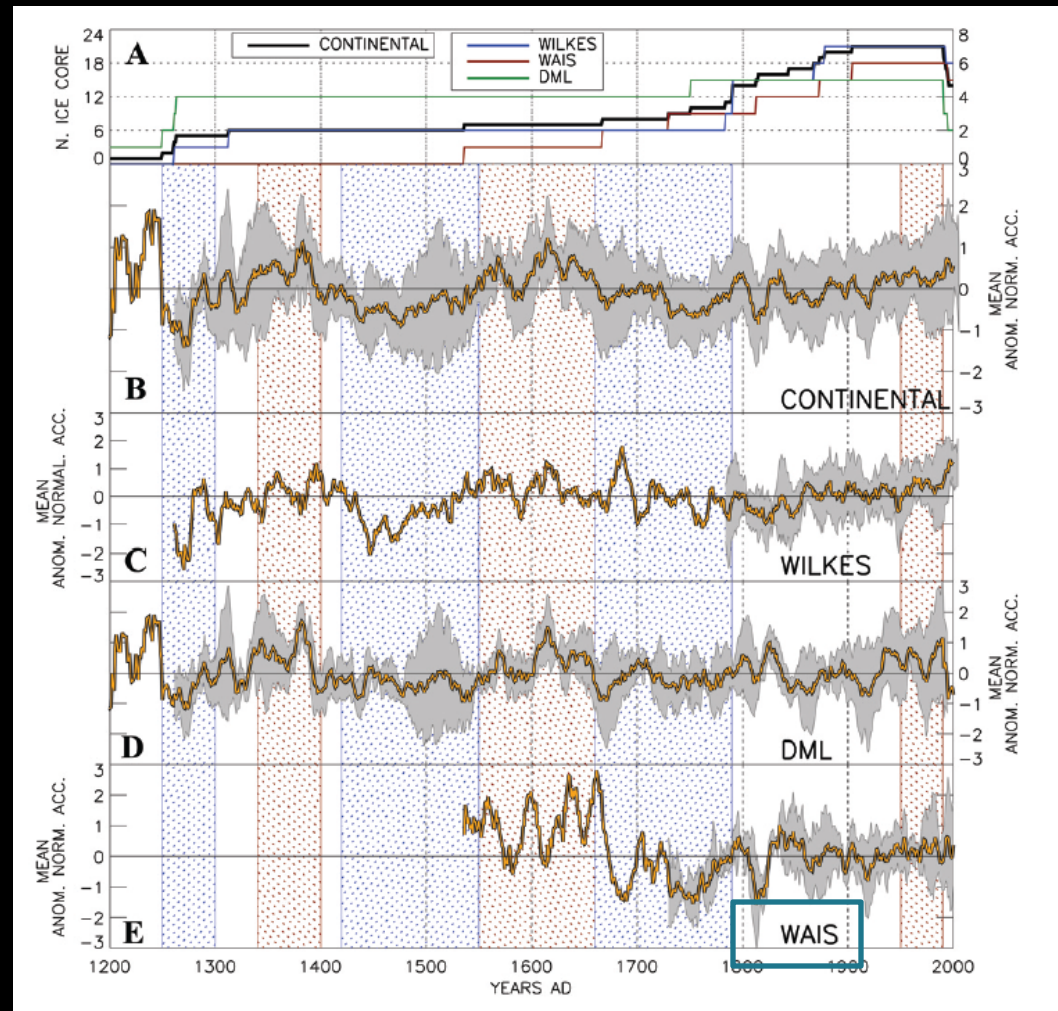
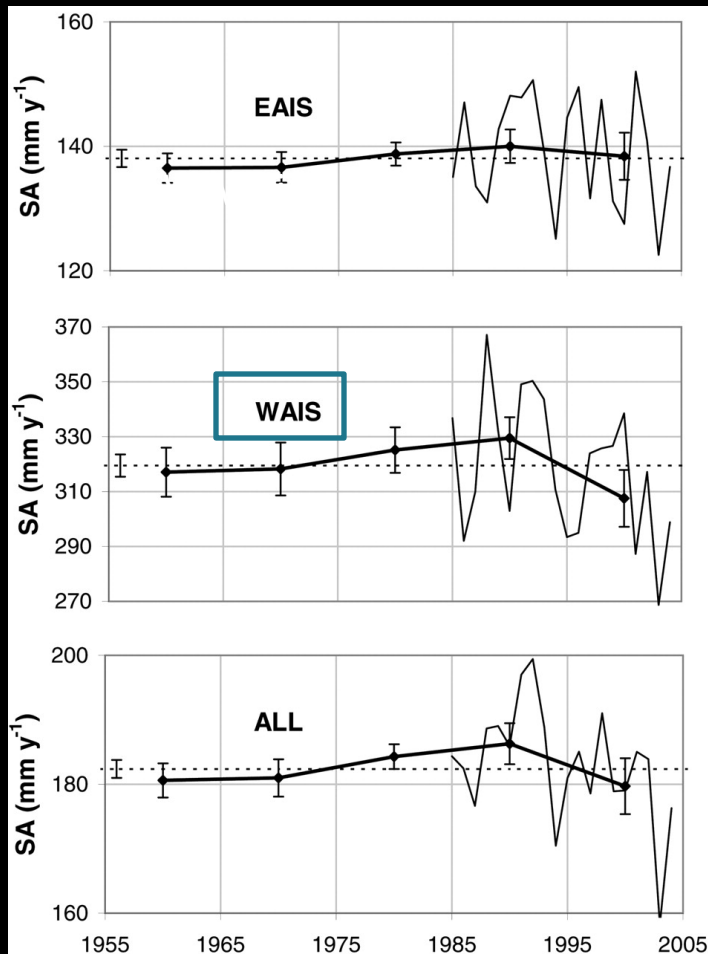
– *Uncertainty propagates*



# What do we know?

Frezzotti et al., *Cryosphere*, 2013

Monaghan et al., *Science*, 2006



# Firn has a memory ☹️

Height change derived  
using the IMAU-FDM  
early 2000 years,  
forced by the firn

It is important that we understand recent surface changes, so we understand the limitations our techniques!



This trend is NOT  
PRESENT when simply  
using the 1979-2010  
surface climate to force  
the FDM



# Monaghan *et al.* (2006) technique

Create a gridded accumulation product through combination of firn core records & atmospheric fields

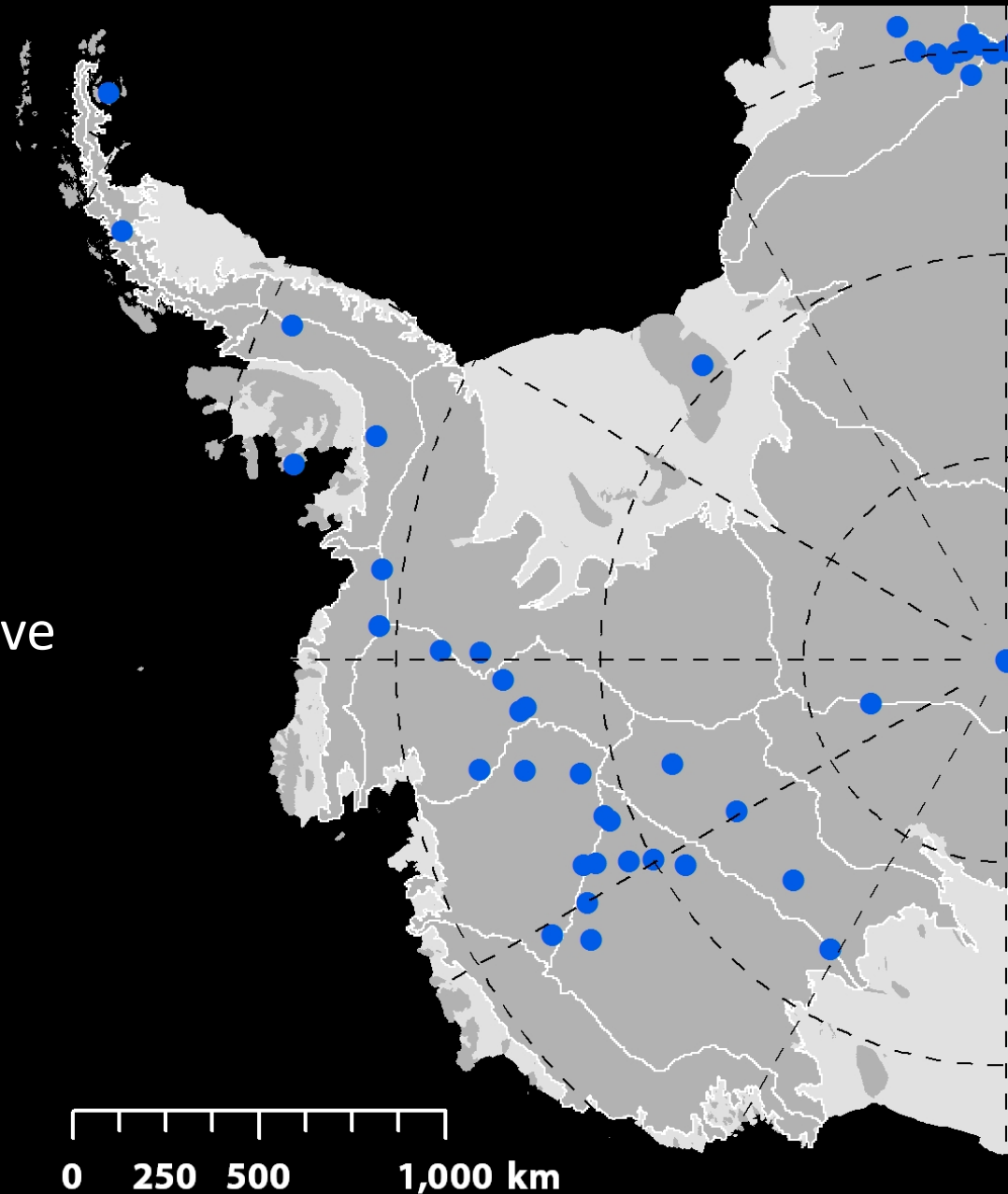
Time → cores

Space → atmospheric grids

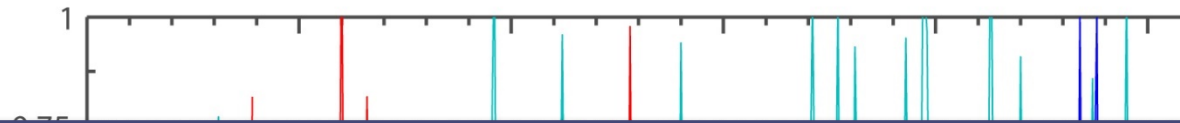
The result: Annual grids of accumulation since 1750

# Core Data Set

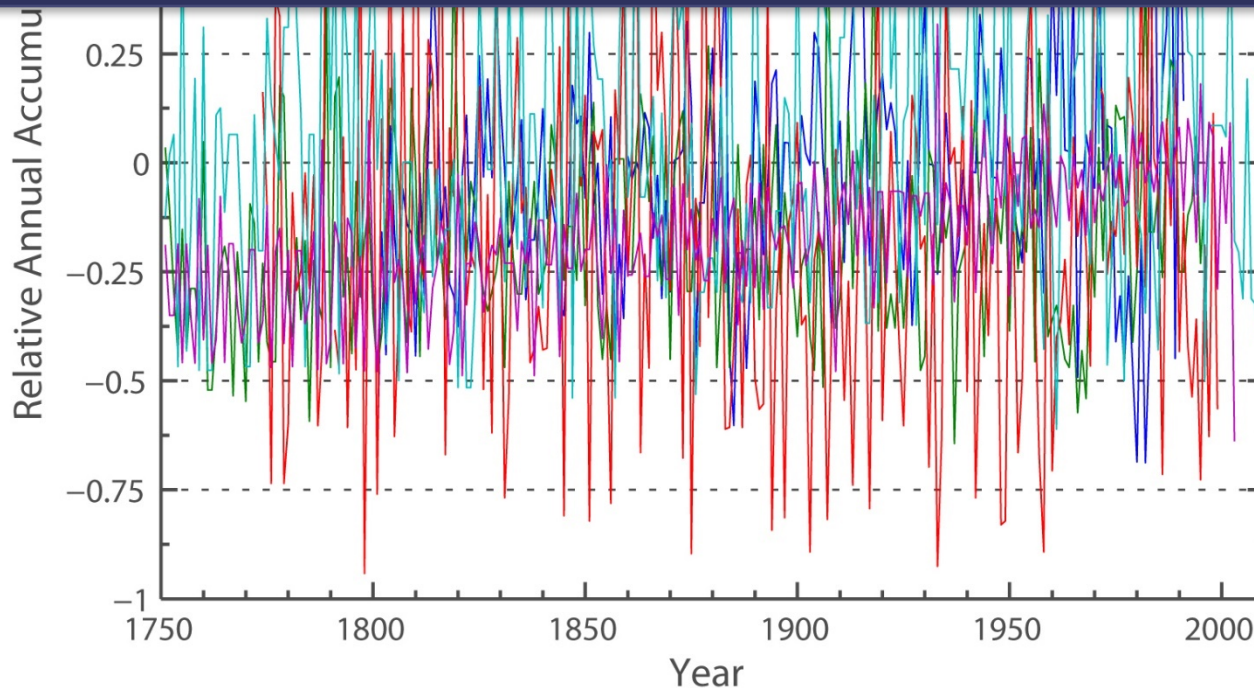
- 81 annually resolved records (WAIS, EAIS, AP)
  - ~30 from WAIS
- Normalized records relative to the 1980-1989 avg



# Five sample core records



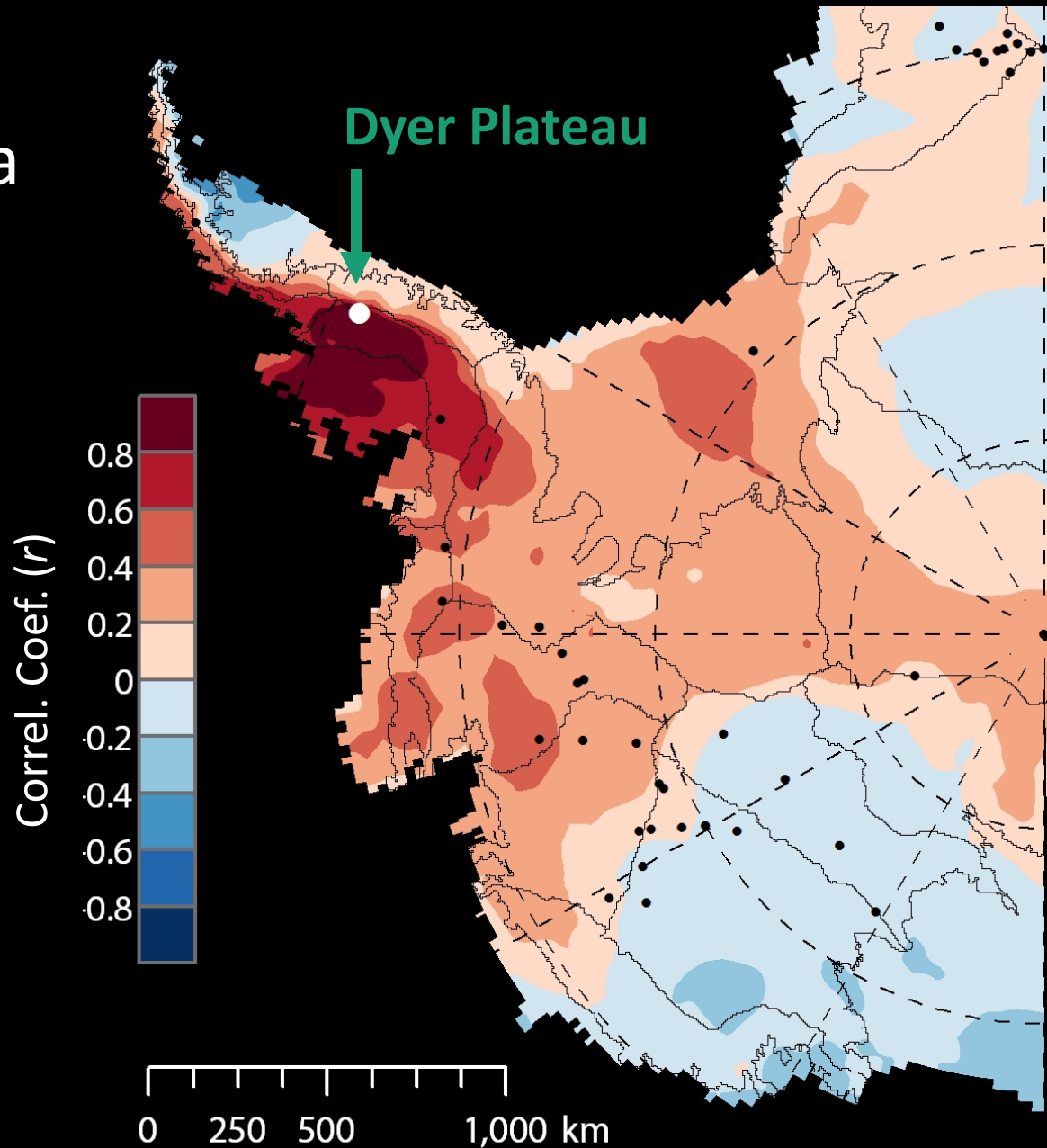
We have the temporal patterns...  
...now we need spatial patterns from MERRA-2





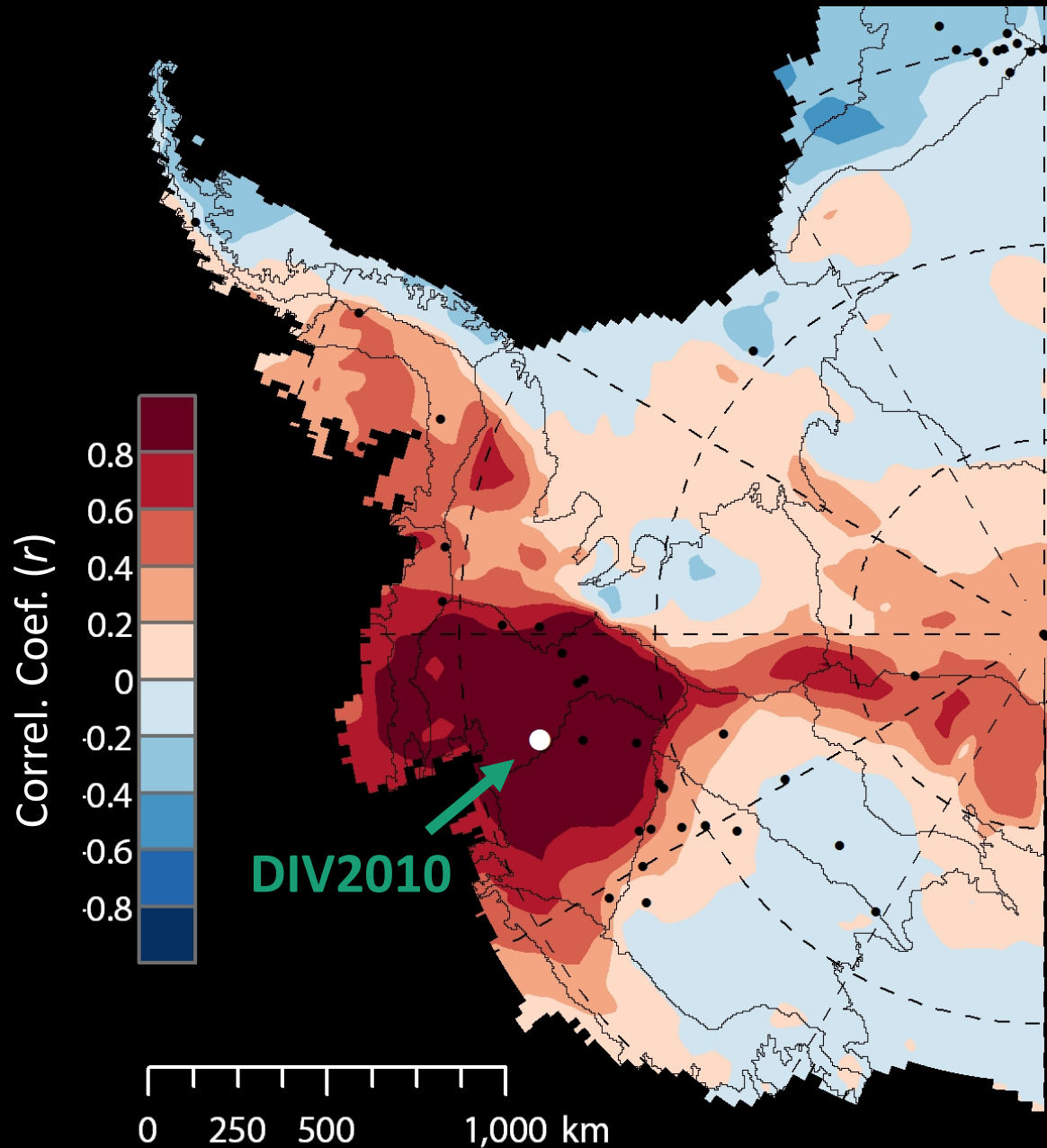
# Correlation Map: Antarctic Peninsula

- Derive a correlation map for each core
- Used to take a weighted average of all records for each cell



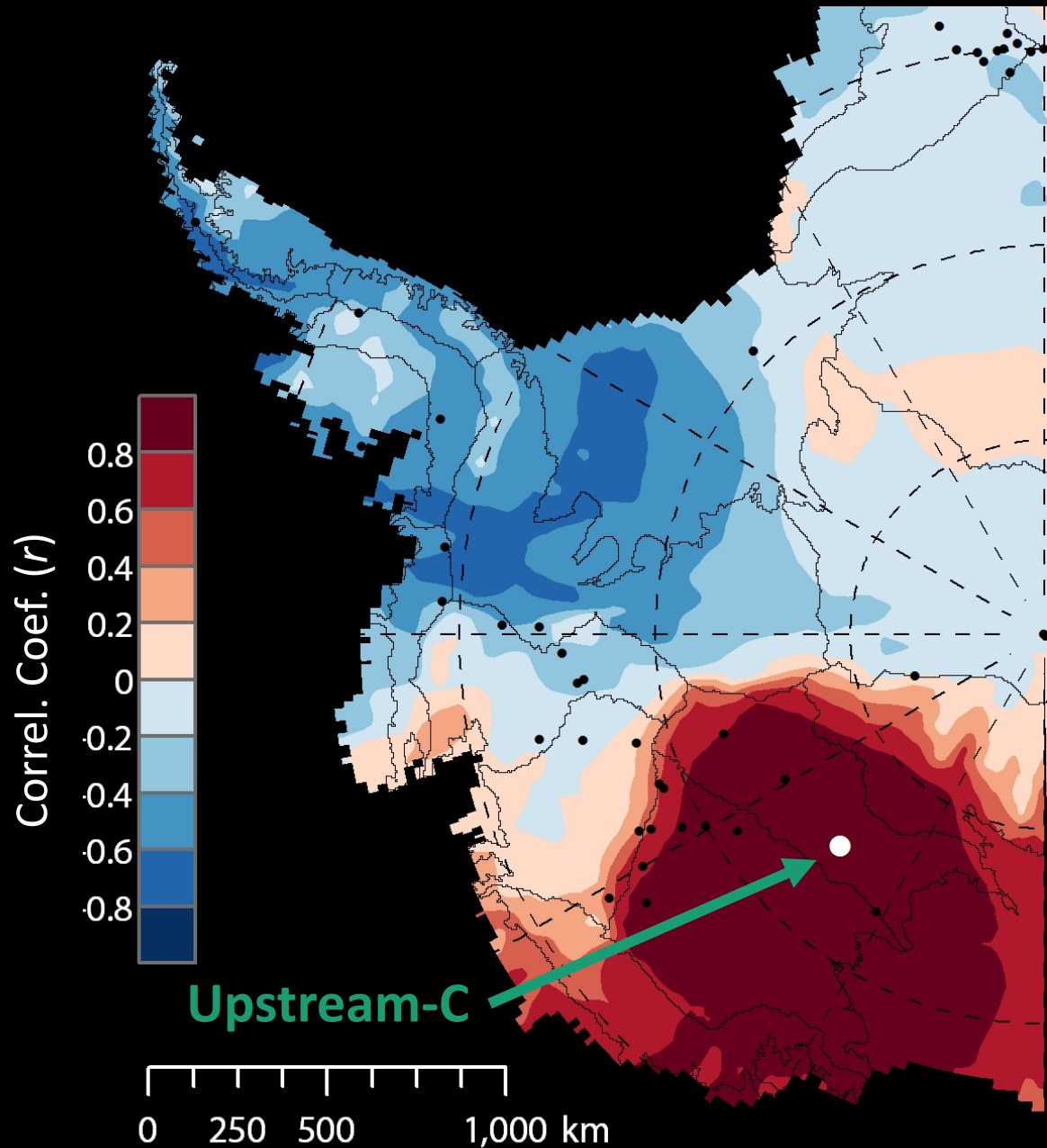
# Correlation Map: Central WAIS

- Strongly related to drainage divides
- Connection to South Pole



# Correlation Map: Western WAIS

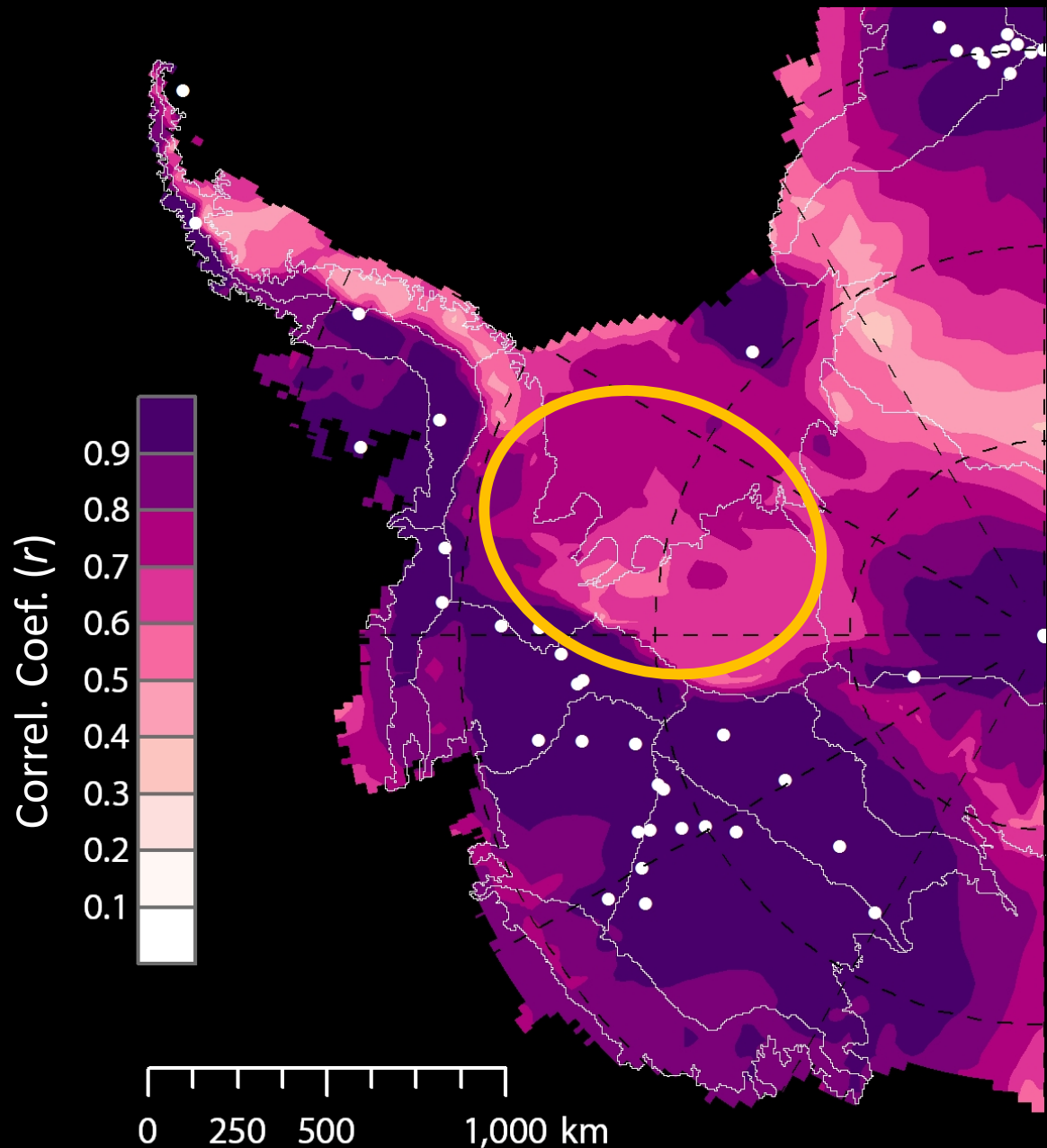
- Seesaw pattern with  
Eastern WAIS and AP





# Maximum Correlation

- Max correlation with one of the cores
- Do our core records cover most of WAIS?
  - Yes!
- Need some cores?  
Or we're missing some!



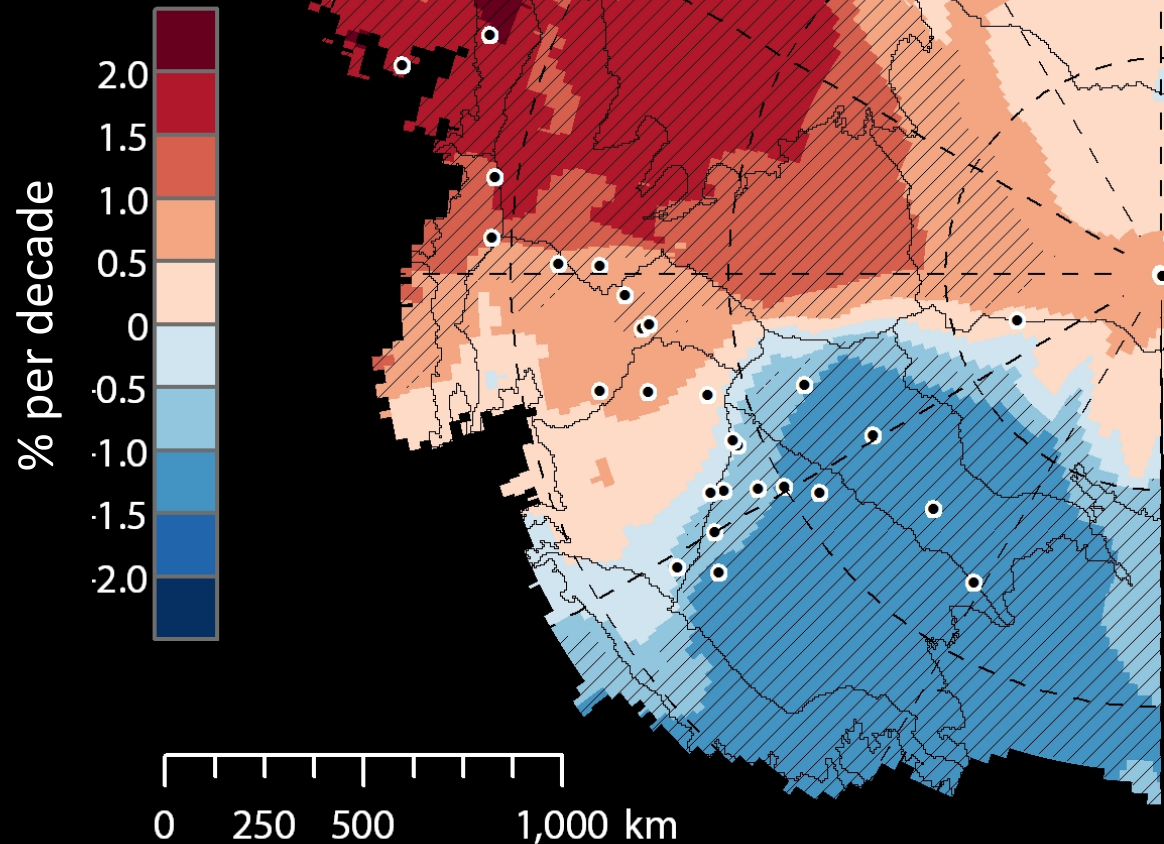
- For each grid cell, weight *ALL* the core records by their  $r^2$  values
- Creates 250-year time series for each grid cell!
  - Let's start with trends over the 20<sup>th</sup> century -

# Century Trend: 1901-2000

Hatching:  $p\text{-value} < 0.01$

Strong opposing trends  
between Eastern and  
Western WAIS

Not much change in  
central WAIS





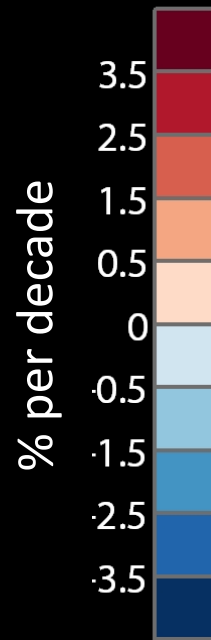
# Mid-Century Trend: 1951-2000

Hatching: p-value < 0.01

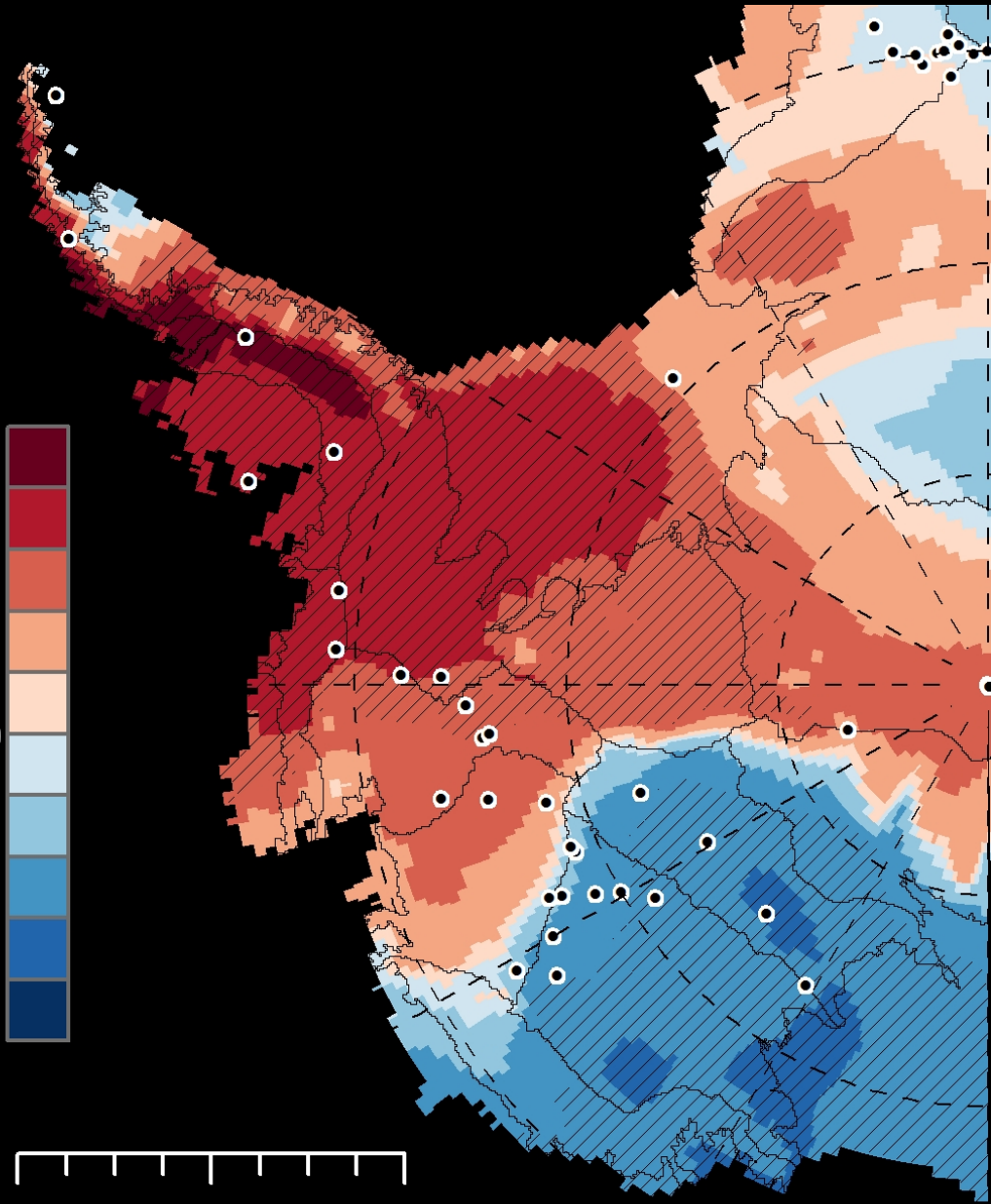
Note scale change!

Strong(er) opposing  
trends between Eastern  
and Western WAIS

No significant change in  
central WAIS



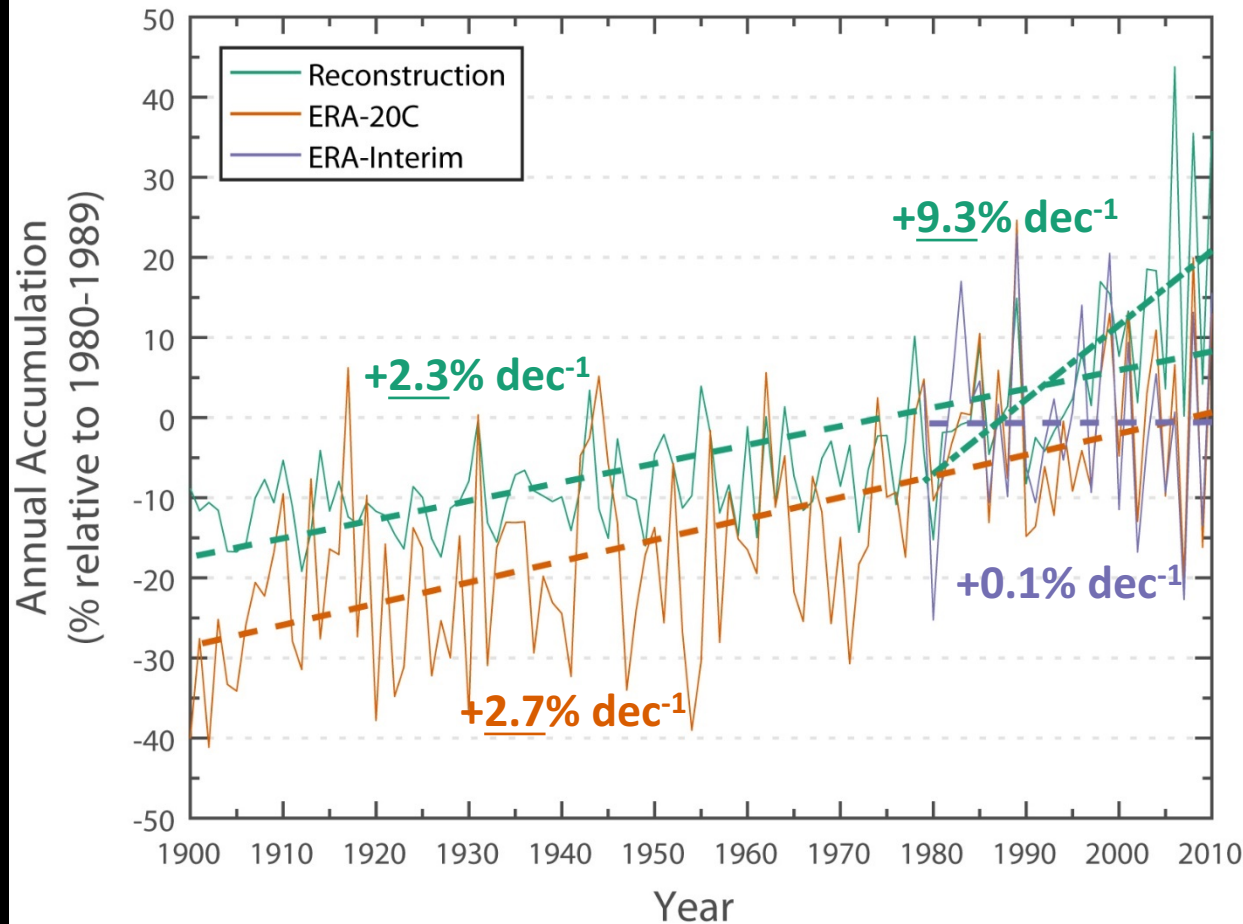
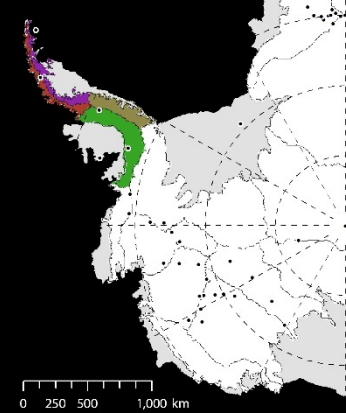
0 250 500 1,000 km



## Comparisons with ECMWF products:

1. ERA-Interim reanalysis (1979-2015)
2. ERA-20C reanalysis (1900-2010)
  - Assimilated observations: surface pressure, winds (no satellite/upper-air data)

# Antarctic Peninsula



Correlation Coef ( $r$ )

1900 – 2010:  
0.44,  $p < 0.01$

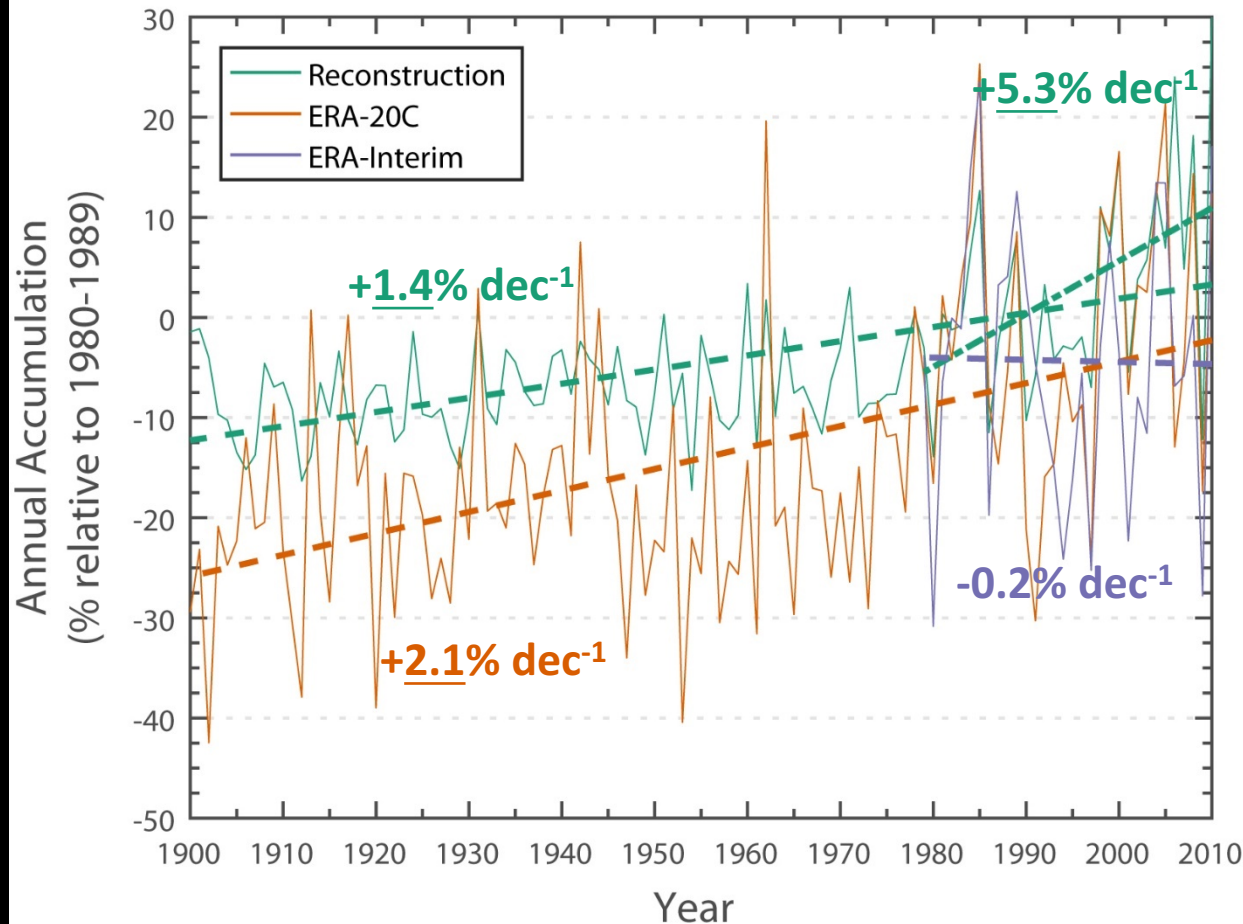
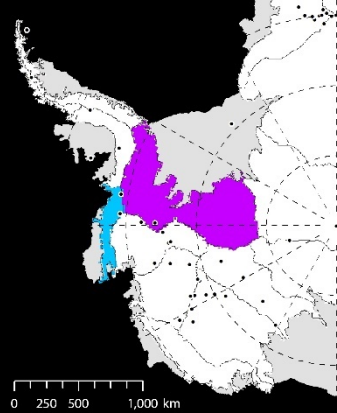
1979 – 2010:  
0.68,  $p < 0.01$

*Based off of  
detrended time  
series*

Underline:  $p < 0.01$



# Eastern WAIS



Correlation Coef ( $r$ )

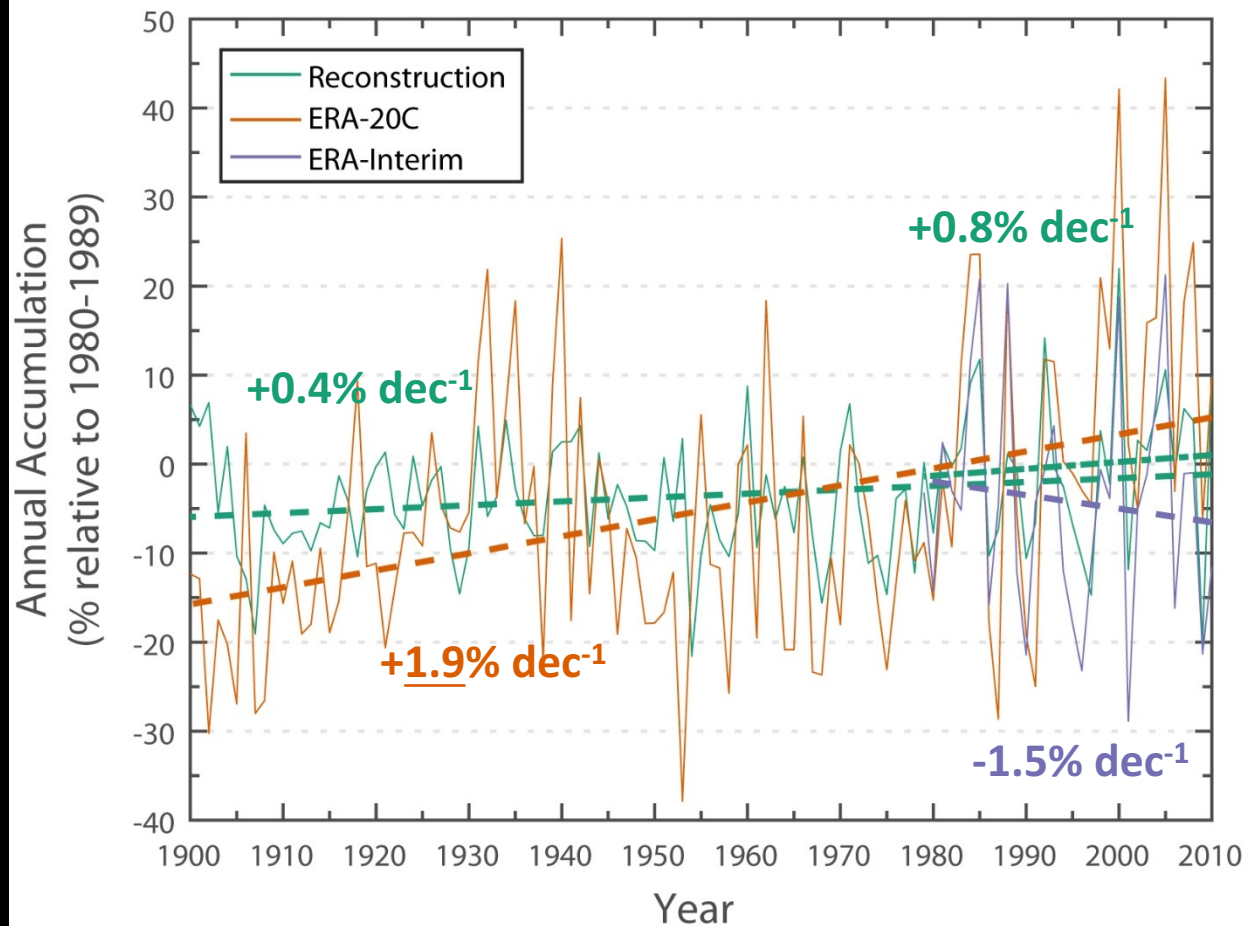
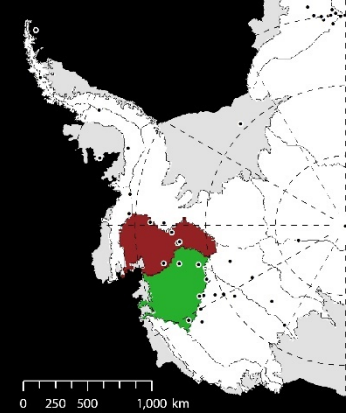
1900 – 2010:  
0.49,  $p < 0.01$

1979 – 2010:  
0.73,  $p < 0.01$

*Based off of  
detrended time  
series*

Underline:  $p < 0.01$

# Central WAIS



Correlation Coef ( $r$ )

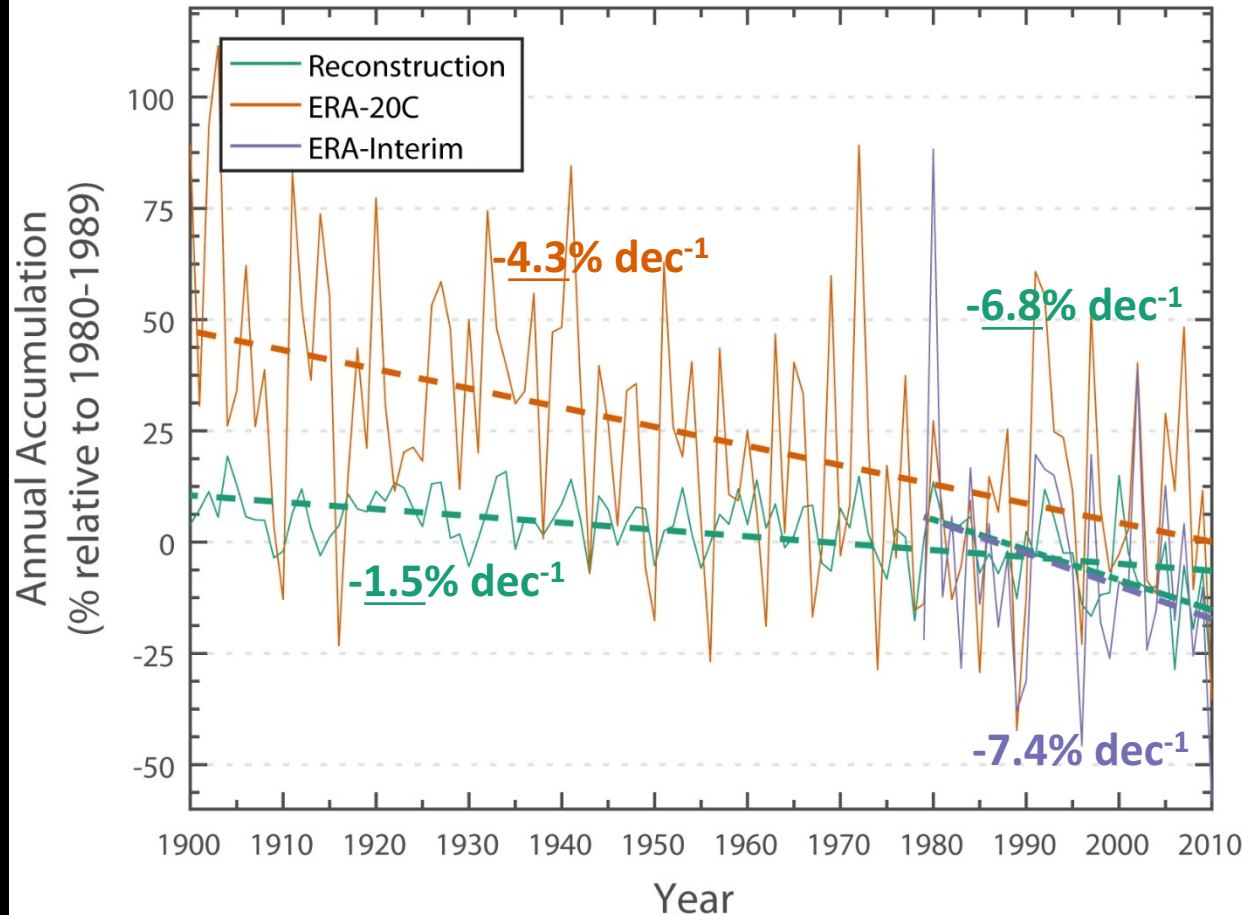
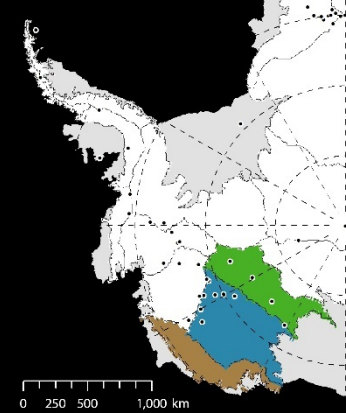
1900 – 2010:  
0.51,  $p < 0.01$

1979 – 2010:  
0.78,  $p < 0.01$

*Based off of  
detrended time  
series*

Underline:  $p < 0.01$

# Western WAIS



Correlation Coef ( $r$ )

1900 – 2010:  
0.24,  $p = 0.01$

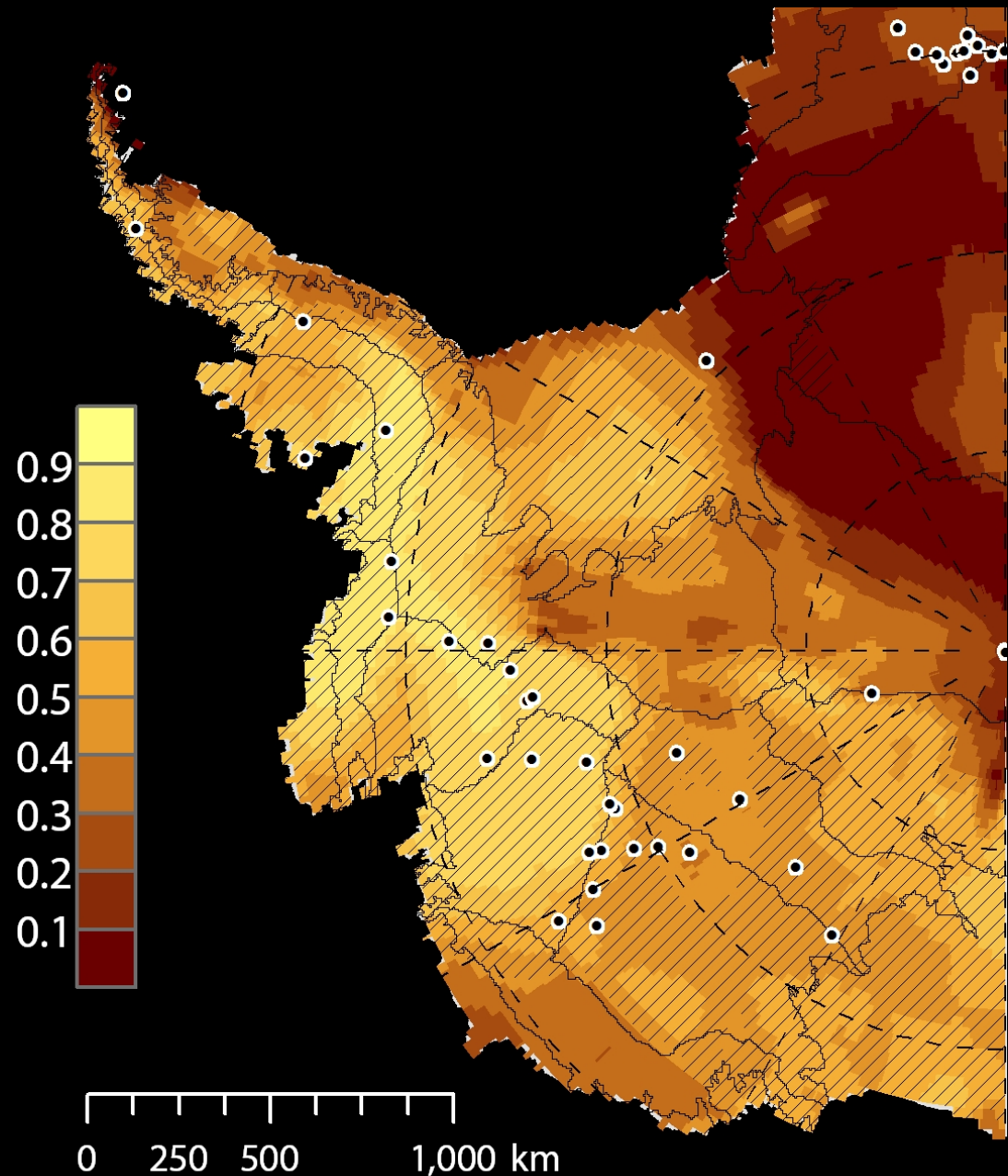
1979 – 2010:  
0.48,  $p < 0.01$

*Based off of  
detrended time  
series*

Underline:  $p < 0.01$

# Comparison with ERA-Interim

- Reconstruction is strongly correlated with ERA-Interim over most of WAIS
- Regions of low correlation are where cores are sparse
- Weaker correlation in W. WAIS is due to the lack of recent cores





# Summary

WAIS Accumulation rates are changing

- *Impact altimetry studies?*

Agreement with models...

- *Trend magnitudes vary*

Future work

- *Understand controls*



# Thanks!

The many hardworking field/lab  
teams that collected/analyzed the  
firn cores

Stefan Ligtenberg, IMAU

WAIS Workshop Organizing  
Committee

NASA/NSF Funding

